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G1S SEA

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US 4900154 A

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INT CL[7] **B60P, G01G, G01L, G01N**
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(54) Abstract Title: **Concrete mixing truck with incorporated monitoring system**

(57) A concrete mixing vehicle 100 having mounted thereon a monitoring system 114. The monitoring system 114 comprises: a memory means 204 arranged to hold data; a processing means 200; a work measuring means 110 arranged to measure at least one of the work required to mix a mix and the rate of mixing of a mix, and generate work data; and a weight acquiring means 116 arranged to acquired the weight of the mix and store the weight data in the memory means 204. The processing means 200 is arranged to process at least one of the work data and weight data, and calculate one or more parameters of the mix, such as the slump of strength of the mix. The monitoring system 114 may be arranged to communicate with a monitoring station. The monitoring system may also monitor driver performance or vehicle condition.

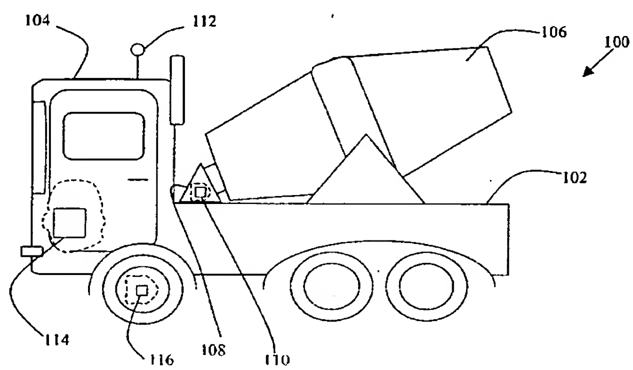


Fig. 1

GB 2 392 502 A

The claims were filed later than the filing date but within the period prescribed by Rule 25(1) of the Patents Rules 1995.

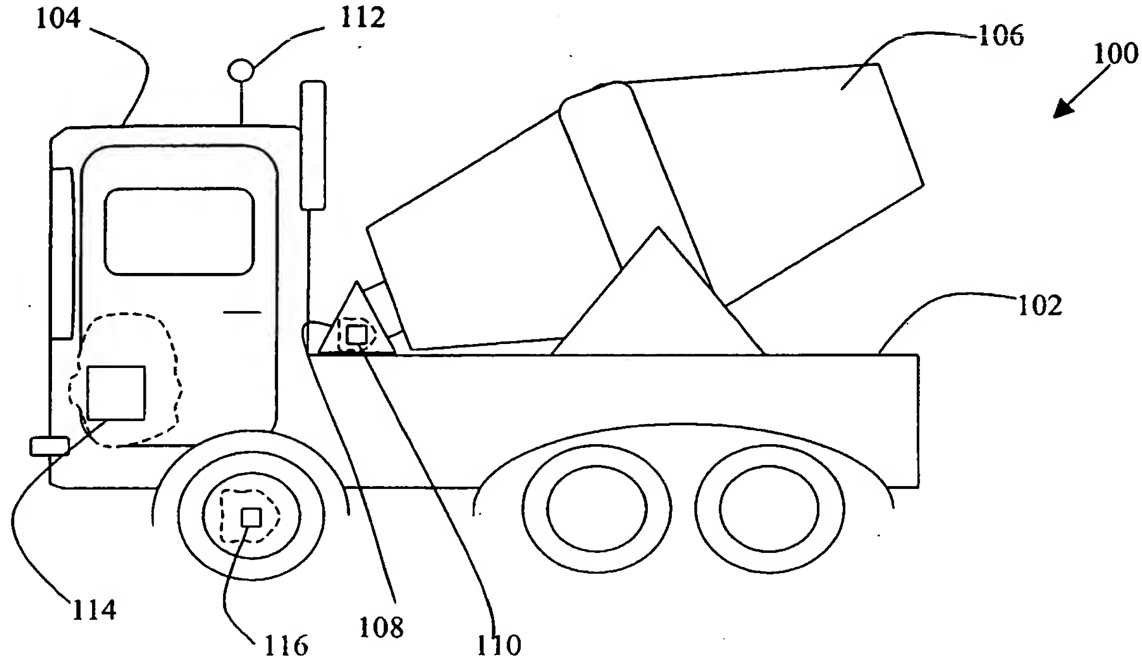

104
112
106
100
102
114
116
108
110

Fig. 1

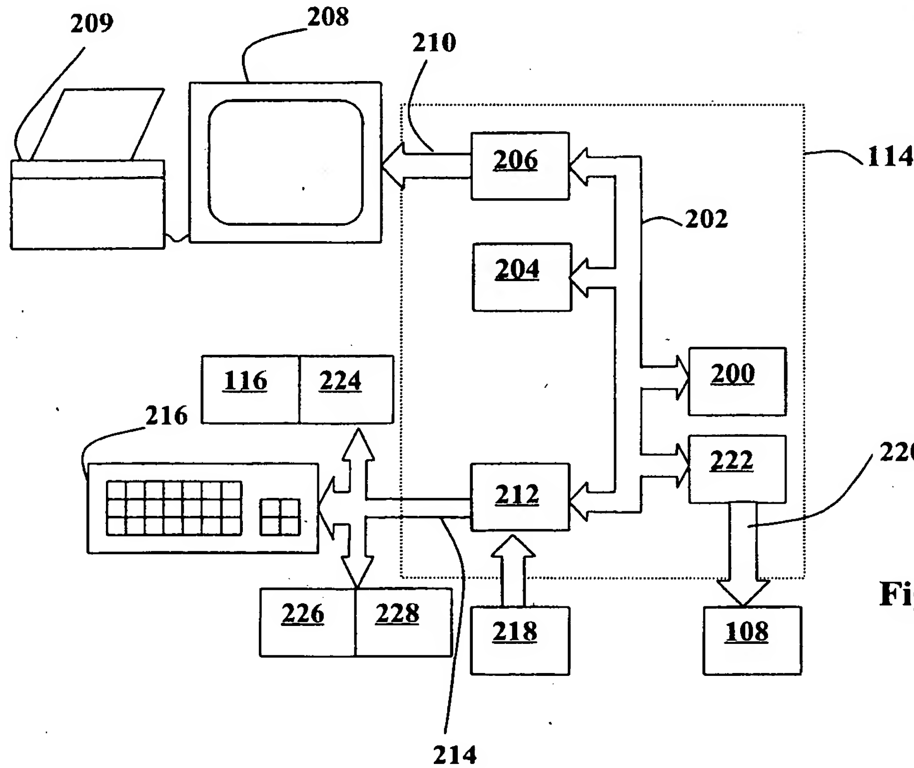

209
208
210
206
114
202
204
200
116
224
216
222
220
212
226
228
218
108
214

Fig. 2

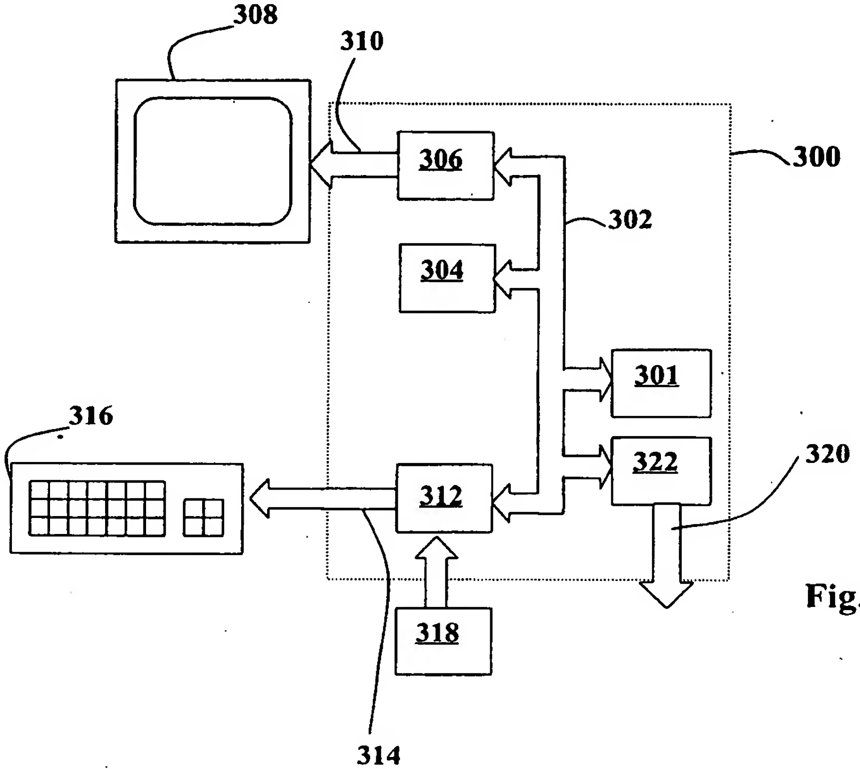
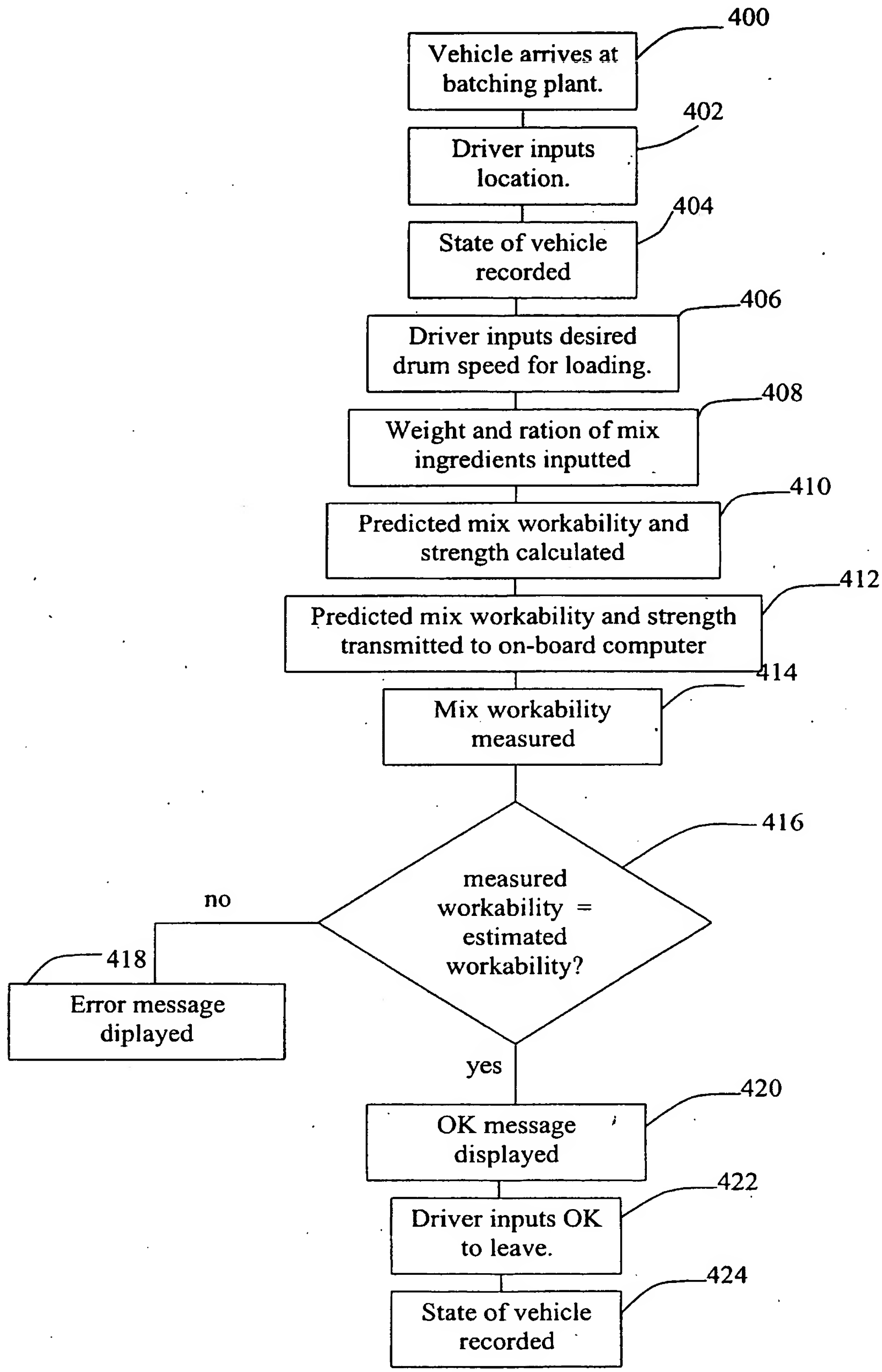


Fig. 3



400
Vehicle arrives at batching plant.
402
Driver inputs location.
404
State of vehicle recorded
406
Driver inputs desired drum speed for loading.
408
Weight and ration of mix ingredients inputted
410
Predicted mix workability and strength calculated
412
Predicted mix workability and strength transmitted to on-board computer
414
Mix workability measured
416
measured workability = estimated workability?
no
418
Error message diplayed
yes
420
OK message displayed
422
Driver inputs OK to leave.
424
State of vehicle recorded

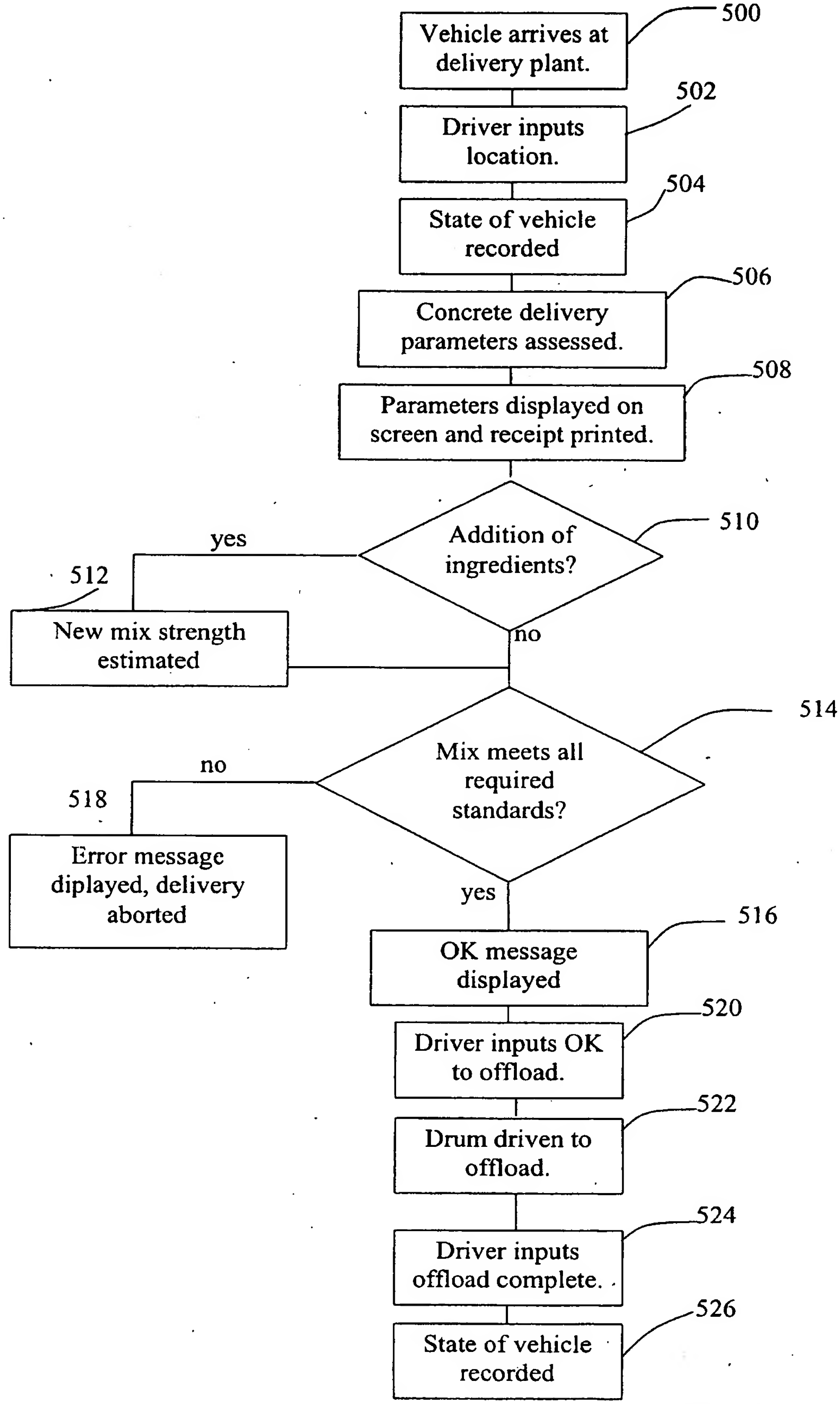

Vehicle arrives at delivery plant.
500
Driver inputs location.
502
State of vehicle recorded
504
Concrete delivery parameters assessed.
506
Parameters displayed on screen and receipt printed.
508
Addition of ingredients?
510
yes
no
512
New mix strength estimated
Mix meets all required standards?
514
no
yes
518
Error message diplayed, delivery aborted
OK message displayed
516
Driver inputs OK to offload.
520
Drum driven to offload.
522
Driver inputs offload complete.
524
State of vehicle recorded
526

Fig. 5

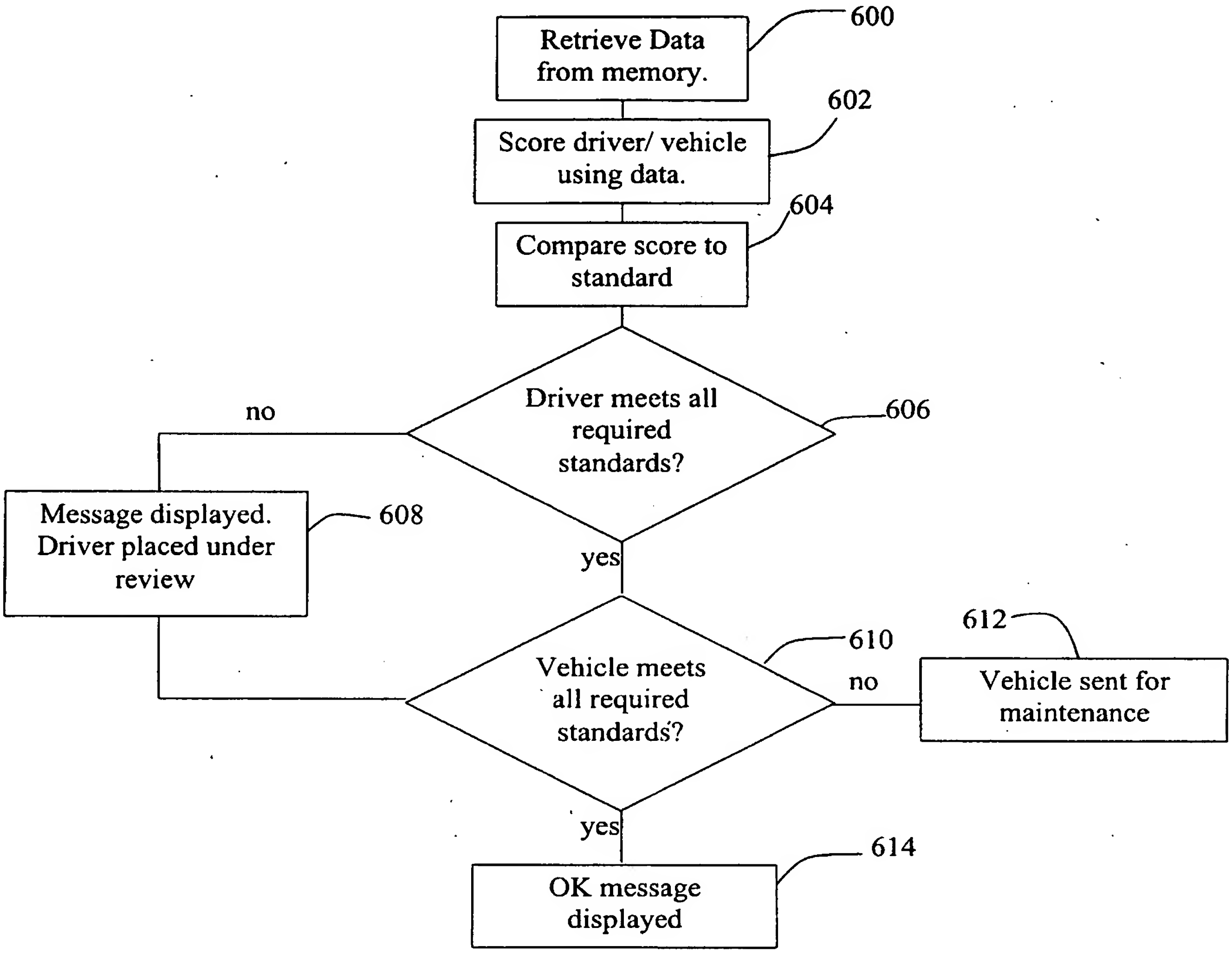

Retrieve Data from memory.
600
Score driver/ vehicle using data.
602
Compare score to standard
604
Driver meets all required standards?
606
no
Message displayed. Driver placed under review
608
yes
Vehicle meets all required standards?
610
no
612
Vehicle sent for maintenance
yes
OK message displayed
614

Fig. 6

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MONITORING A CONCRETE MIXER

This invention relates to management of a concrete mixing vehicle and further to the management of a fleet of concrete mixing vehicles.

Various means of monitoring concrete mixing vehicles are known. For example, remote monitoring of the concrete within a concrete mixer has been previously proposed (GB 2 329 027). The monitoring of various other parameters in relation to the concrete mixing vehicles is also known. For example, it is known to use a tacheograph to monitor the number of hours that a driver has been driving the vehicle.

Concrete mixed by such concrete mixing vehicles can be used to construct important structures such as bridges, buildings, etc. As such, it is an important consideration that the concrete meets predetermined characteristics (for example minimum strength) in order that the structure is safe. It is therefore advantageous to monitor the condition of concrete being mixed by the vehicle.

Traditionally, a sample of the concrete mixed by the truck has been taken when the concrete is poured in vicinity of the structure and later tested. The results of such testing can take upwards of twenty-four days to become fully known. It will be appreciated that if large structure has been built with concrete that fails a test then the validity of the structure is put into question and it may have to be destroyed. Historically therefore, there has been a tendency to make the mix overly strong, by adding extra cement, in order that it does not fail the testing. Cement is generally the most costly component of the mix and therefore, this making the mix overly strong increases the cost of the mix in turn making it less profitable for the manufacturer.

Indeed, properties of the mix within the concrete mixing vehicle can vary during transit of the vehicle from a batching plant, where it was loaded to, a point where the mix is required. This may occur due to high temperatures within the vehicle (which causes water to evaporate), delays in transit, addition of water by delivery vehicle drivers, building site workers, etc. It is therefore desirable to have a convenient means of independently checking the slump value of a specific concrete mix in order to provide a level of accountability for the concrete mix delivered by the vehicle.

There is therefore a desire to increase the amount of data that is available about a mix.

According to a first aspect of the invention there is provided a concrete mixing vehicle having mounted thereon a monitoring system, said monitoring system comprising a memory means arranged to hold data, a processing means arranged to process data, a work measuring means arranged to measure at least one of the work required to mix a mix and the rate of mixing of a mix and generate work data, and a weight acquiring means arranged to acquire the weight of a mix and store in said memory weight data, said processing means being arranged to process at least one of the work data and weight data and calculate one or more parameters of a mix.

An advantage of such an arrangement is that the processing means can be used to determine a more accurate determination of the properties of the mix.

The processing means may be arranged to generate parameter data for the parameter that is calculated. Further, the processing means may be

arranged to calculate any one or more of the following parameters: the slump of the mix; the strength of the mix or any other parameters specific to the application of the mix. It is advantageous to be able to calculate the slump because this parameter not only provides an indication of the workability of the mix, but also give a good indication of the strength of the mix.

Furthermore, the processing means may be arranged to compare a parameter measured at one time with the same parameter calculated at a different time. It is advantageous to detect any changes in the slump and/or the strength as this may impact on the quality of the concrete.

It will be appreciated that the parameters may be calculated using variables dependent on the mix. Alternatively, the desired parameters may vary according to the proposed use of the mix. For example, if the structure for which the concrete is intended is likely to be exposed to harsh chemicals or frost, it may be wise to add 'admixtures' of platicizer or air-entrainer. Adding plasticizer improves the compressive strength of the concrete and the proportion of cement in the concrete may be reduced, Air-entrainer reduces the desirable water-cement ratio in the mix.

The weight acquiring means may be a means that determines the weight of a mix, such as for example, one or more load cells, scales, or other suitable mechanism. Such an arrangement has the advantage that the actual weight of vehicle may be determined. It will be appreciated that mix may build up within a concrete mixing vehicle and thus the weight of the vehicle may increase over time. If the actual mass of the mixing vehicle/vessel is known, for example by the use of weight acquiring means that determines this, then it may be possible to help overcome overloading vehicles.

Furthermore, the weight determined by the weight acquiring means may be compared to an expected weight. This may be advantageous in that it provides a check for the weight acquiring means. If the weigh acquiring means produced incorrect data, this would lead to false reading for the slump or strength. If the determined weight differs by more that a predetermined amount from the expected weight, then the weight acquiring means may be assumed to be faulty and subsequent strength and slump measurements should be disregarded as they are likely to be misleading.

The weight acquiring means may comprise two or more separate means one of which may be more accurate than the other. For example, the weight acquiring means may comprise two sets of load cells. It will be appreciated that, generally, more accurate weight acquiring means are more expensive than less accurate ones. Therefore, it may be advantageous to have two weight acquiring means; one less accurate for general use and a more accurate one for occasional use. If the weight acquiring means are used in this manner the more expensive, more accurate means may last longer since it is being used less.

A further advantage of providing a weight acquiring means that determines the weight of a mix is that it may allow part loads to be delivered. Currently, it is not permitted for a vehicle to deliver part of a mix to first site, and second and subsequent parts of a load to different sites, since there is no mechanism for reliably determining what has been delivered. However, by providing a weight acquiring means that determines the weight of a mix may allow this.

Alternatively, or additionally, the weight acquiring means may be an input allowing the weight of a mix to be input to the memory. For example, the weight of a mix and/or the weight of components of the mix

may be input to the memory as the mix/components is added to the vehicle. Such an arrangement has the advantage that it removes the need for accurate weighing means to be placed on the vehicle. However, this method does not take into consideration the build up of dried mix within the vehicle and may not help prevent the vehicle running overweight.

It will be appreciated that a mix as mixed be a concrete mixing vehicle comprises a number of components which may be any one or more of the following: cement; cement; sand; aggregate; water; additives. The additives are generally one or more of the following, but could be others: plastisizers, air-entrainers, reinforcing fibres, colourings, or the like.

The memory means may be arranged to contain data giving the properties of a mix as the relative quantities of the one or more of the components of the mix change. Such an arrangement is advantageous because it allows the effect of a change in quantity of one of the components to calculated on the mix as a whole. The memory means may be arranged to keep data so that the change in quantity of any 1, 2, 3, 4, 5, 6, 7, 8, or more components may be calculated. Such an arrangement is sometimes referred to as a "curve".

Further, the memory means may be arranged to hold the physical properties of one or more of the components. For example, the memory means may be arranged to hold any one or more of the density, the compressive strength, the moisture content, the granular size of the components. Such an arrangement may allow a change in volume to be calculated from a change in weight and visa versa.

The monitoring system may comprise a flow meter arranged to determine the amount of a component added to the vehicle and to generate flow data. Commonly, the flow meter may be arranged to determine the

amount of water that is added to the vehicle, but may be used to determine the amount of any of the components to a mix to be determined.

The weight acquiring means may be arranged to determine the weight of a component and/or the mix by utilising the flow data generated by the flow meter. It may be particularly convenient to utilise physical properties about the component and/or mix held within the memory means.

The monitoring system may comprise a temperature measuring means arranged to measure the ambient temperature and/or the temperature of the mix and therefore to generate temperature data. Such an arrangement is convenient because it allows it to be determined whether or not the mix was delivered within parameters. The skilled person will appreciate that the ambient temperature must be above a predetermined temperature, currently 2°C, for a mix to be delivered. If this is not the case then the mix can be damaged, or rendered useless, by the formation of ice crystals within the mix. It therefore increases the accountability for the operator of the vehicle if the temperature is recorded.

Conveniently, the work measuring means comprises any one or more of the following: a means to measure the hydraulic pressure in a hydraulic circuit used to mix the mix (generally a hydraulic motor used to rotate a drum), a means to measure the load on an engine of the vehicle, a means to measure the power take off (PTO), a means to count a point on a mechanism past a predetermined point (for example count rotations of a drum, tooth of a drive cog, or the like).

In what is perhaps a more preferred embodiment of the present invention the work measuring means comprises a means to measure the pressure in a hydraulic circuit and a means to measure the speed of rotation of a

drum used to contain the mix. Such an arrangement is convenient because it allows the speed of the drum to be determined and also the slump of the mix to be determined.

The skilled person will appreciate that there are requirements as to the amount of mixing that a mix must undergo before it is delivered. For example some countries may have legislation that requires one or more of the following: the mix to be mixed at a predetermined speed during loading thereof; the mix to be mixed at a predetermined speed during transportation thereof; the mix to mixed at a predetermined speed during delivery/unloading thereof. Further, knowing the effort required to rotate a drum used to hold the mix is convenient because it allows the slump of the mix to be determined. Slump may be thought of as the workability of the mix and can be used to give an indication of the strength of a mix.

In some embodiments the monitoring system may comprise a time generating means arranged to generate time data. Such time data may be used by the processing means to ascertain any one or more of the following: the time of predetermined points (for example time of delivery, time load of the mix occurred, time that mixing started/stopped), time that a driver drives the vehicle, or any other pertinent time. It is convenient to record the predetermined points to help ensure that the mix has been mixed for periods specified, or that it has not been too long loading and delivery of the mix. It is convenient to record the hours that a driver has worked to try and help ensure that working time directives are met.

The monitoring system may comprise an approval recording means. When a mix of concrete is delivered to a point of delivery, the quality of the mix is the responsibility of the company/person that mixes the mix and delivers it up until the point of delivery. When the mix is delivered

it is generally approved by a person and accepted. It is generally important for the company/person delivering the mix to record this acceptance so that there is an accountable hand over in the responsibility for the quality of the mix. Such an approval recording means may provide such a mechanism.

In one embodiment the approval recording means comprises a printing means that is arranged to print a document for signature by the person accepting the mix. The printed document may be arranged to contain any one or more of the following: the quantities (relative and/or absolute) for one or more of the components of the mix; one or more parameters calculated from the mix; the temperature of the mix; the location of the vehicle; the route of the vehicle; the time; the speed of the drum during delivery of the mix; or any other data.

The approval recording means may alternatively, or additionally, comprise an electronic means allowing a person to electronically record his/her approval (approval data) in the memory means.

In some embodiments the monitoring system comprises a display means arranged to display any of the data generated by the system.

The monitoring system may comprise a positioning means arranged to generate position data giving the position of the vehicle, which may be a GPS receiver. The memory means may be arranged to record the position data. Such an arrangement is convenient because the position data can be used to increase the accountability of the vehicle, can be used to provide route planning information, and may help to reduce the time taken to load a vehicle with a mix. The accountability may be increased if the route of the vehicle can be shown. For example, drivers may be less likely to take detours and deliver parts of his/her load fraudulently, if the route of the

vehicle can be easily proven. The time taken to load the vehicle may be reduced if it can be determined that a vehicle is close the point in which it will be loaded, and once this has been determined preparations to load the vehicle may commence before the vehicle reaches that point.

The monitoring system may comprise a camera arranged to provide a view of a region behind the vehicle (behind the vehicle picture data). Such an arrangement is advantageous because it may make reversing a vehicle safer. The display of the monitoring system may be arranged to display the picture produced by the camera.

In one embodiment the display may be a portion of a satellite navigation system which is also used to display the picture of the reversing camera. Such an arrangement is convenient because it can help to reduce the amount of equipment within the vehicle..

Further, the monitoring system may comprise a camera arranged to provide a view (inside of the drum picture data) of the inside of a drum used to mix the mix. Traditionally one method of determining the quality of the mix is by visual inspection. However, this has necessitated a person climbing a ladder and looking into the drum. Not only is this prior art method hazardous for that person, but the weight of the vehicle is increased by the presence of the ladder. Therefore, the use of a camera is advantageous because it makes visual inspection cheaper and it also may increase the efficiency of the vehicle by making it lighter.

Again, the display of the monitoring system may be used to display the picture generated by a camera inside a drum used to mix the mix.

The monitoring system may comprise a transmitter and/or receiver arranged to transmit any of the data generated by any part of the

monitoring system and/or receive data. For example the receiver may be arranged to receive data relating to any one or more of the position of the vehicle; the quantity of any of the components of the mix.

The vehicle may comprise a speed varying means which allows the speed of mixing of the mix to be controlled. In some embodiments this may comprise a means to alter the speed of rotation of a drum used to hold the mix. The monitoring system may be arranged to have one or more inputs to the speed varying means in order that the speed of mixing can be controlled by the monitoring system. Such an arrangement is convenient because it allows the properties of the mix to be controlled.

The monitoring system may be comprise an input means, which may be a keyboard, a keypad, joystick, button, touch screen, or any other suitable input mechanism.

In some embodiments the monitoring system may also have one or more inputs thereto which are arranged to provide vehicle condition data which provide an indication as to the performance of the vehicle. For example, the inputs may include any one or more of the following: fuel remaining; fuel consumption; acceleration (positive and/or negative (i.e. braking)); tyre pressures. Such inputs are advantageous because they may be able to provide an indication as to problems with the vehicle (e.g. using too much fuel, puncture, etc.) or they may be able to give an indication of poor driving on the part of the driver (accelerations which are too high, excessive fuel consumption, etc).

The monitoring system may be arranged to record any one or more of the data items generated within the memory means. Such an arrangement increases the accountability of the mix carried and/or mixed by the vehicle. The memory means preferably comprises at least a portion

which is non-volatile so that data is not lost should power be lost. The memory means may for example comprise any one or more of the following: a hard disk drive; a non-volatile memory; a volatile memory; any form or recordable CD or DVD medium. For the avoidance of doubt the memory means may be arranged to record any one or more of the following: work data; weight data; parameter data; flow data; time data; approval data; position data; behind the vehicle picture data; inside of the drum picture data; temperature data; vehicle condition data.

According to a second aspect of there is provided a method of monitoring the mix being mixed by a concrete mixing vehicle comprising generating work data be measuring at least one of the work required to mix the mix and the rate of mixing the mix and acquiring weight data of a mix, and further, processing said weight and said work data in order to calculate one or more parameters of a mix.

The method may obtain the weight data by a weighing means provided on the vehicle, or may obtain the weight data by transmission thereto.

According to a third aspect of there is provided a monitoring station arranged to communicate with at least one monitoring system fitted to a concrete mixing vehicle according to a first aspect of the invention and arranged to receive data generated by the monitoring system.

Such a monitoring station is advantageous because it can allow operators remote from the concrete mixing vehicle to ascertain anything about the vehicle and/or mix that is defined by the data. The monitoring station may be a substantial distance from the vehicle: for example, the monitoring station may be kilometres, tens of kilometres, hundreds of kilometres, thousands of kilometres from the vehicle.

Conveniently, the monitoring station may receive data from the monitoring system by any suitable transmission medium. Examples, which are not intended to be exhaustive of suitable transmission media include; wireless telephone networks (including GSM, GPRS, UTMS), radio links, satellite links, or the like.

According to a fourth aspect of the invention there is provided a method of monitoring at least one vehicle, and preferably a fleet of vehicles, comprising providing the or each vehicle with a monitoring system and connecting that monitoring system to a monitoring station via a transmission medium and causing said monitoring station to receive data from the monitoring system.

According to a fifth aspect of the invention there is provided a monitoring system suitable for fitting to a concrete mixing vehicle, said monitoring system comprising a memory means arranged to hold data, a processing means arranged to process data, a work measuring means arranged to measure at least one of the work required to mix a mix and the rate of mixing of a mix and generate work data, and a weight acquiring means arranged to acquire the weight of a mix and store in said memory weight data, said processing means being arranged to process at least one of the work data and weight data and calculate one or more parameters of a mix.

According to a sixth aspect of the invention there is provided a method of monitoring the inside of a mixing vessel of a concrete mixing vehicle comprising placing a camera, or other remote viewing facilitation means, inside the mixing vessel.

The mixing vessel may be a drum, which may be arranged to rotate about an axis thereof.

Traditionally a mix held within a mixing vessel has been visually inspected, which has put the person performing the visual inspection in a dangerous position. Further, it generally necessary to provide a ladder or other access means allowing a person to gain access to the mixing vessel in order to view the mix inside. Therefore removing the need for a person to view the inside of the vessel is advantageous because it removes a dangerous job and can make the vehicle lighter and therefore more efficient.

According to a seventh aspect of the invention there is provided a method of increasing the safety of vehicle comprising using the display of a satellite navigation system to display the view from a camera viewing behind the vehicle.

Such a method may be advantageous because it uses equipment that may already be provided within the vehicle in order to increase the available space within the vehicle.

According to a eighth aspect of the invention there is provided method of reducing the time taken to load a vehicle comprising utilising position data giving the position of the vehicle to determine when the vehicle is within a predetermined distance, or predicted time of, a site and commencing preparation to load the vehicle at that site before the vehicle arrives.

Such a method is advantageous because it may reduce operating costs of the vehicle and/or the site that is to load the vehicle.

According to a ninth aspect of the invention, there is provided a monitoring system for a concrete mixing vehicle comprising a computing device arranged to receive inputs, said inputs comprising at least two of:

at least one parameter indicative of the condition of a load of concrete carried by the truck;
at least one parameter indicative of driver performance; and
at least one parameter indicative of the condition of the truck.

An embodiment of the invention is now described by way of example only and with reference to the accompanying drawings of which:

Figure 1 shows a representation of a concrete mixing vehicle arranged to operate according to the embodiment of the present invention described herein;

Figure 2 shows a mobile computing system adapted to provide the method of the embodiment of the present invention described herein;

Figure 3 shows a stationary, prior art, computing device arranged to provide inputs to the mobile computing device; and

Figures 4, 5 and 6 show flowcharts of the processes undergone in carrying out aspects of one embodiment of the present invention

The concrete mixing vehicle 100 shown in Figure 1 comprises a truck base 102 on which is mounted a cab 104 and a rotatable drum 106, providing a mixing vessel and, driven by a motor 108. Linked to the motor 108 is a controller 110, arranged to count the number of revolutions the drum 106 performs, to control the speed at which the drum rotates and to monitor the hydraulic back pressure (i.e. a measure of the resistance felt by the drum when rotating). The speed at which the drum rotates and the hydraulic back pressure may be used to generate work data to be input to a monitoring system described hereinafter.

The truck further comprises an aerial 112 mounted on exterior of the cab 104. Linked to the suspension of the vehicle 100 is a load cell 116, providing a weight acquiring means, which measures the weight of the vehicle. Within the cab 104, there is a monitoring system 114 shown in more detail in Figure 2 and described below.

There is a flow meter (not shown) attached to the drum 106 arranged to determine the quantities of liquids poured into the drum. The flow meter comprises a 'propeller meter', i.e a propeller that turns as a liquid flows past. A reed switch on the propeller is arranged to provide electrical pulses indicating the number of revolutions performed by the propeller and thereby indicated the volume of liquid that has passed over the propeller.

The monitoring system comprises 114 a mobile computing device which further comprises a processor 200 connected, via a bus 202, to a memory means 204. The bus 202 also connects the processor 200 to a display driver 206, which drives a display 208 connected to an output interface 210. Also connected to the output interface 210 is a printer 209. An input/output controller 212 is also connected to the bus 202 and to a keyboard 216, a digital thermometer 224 (a temperature measuring means arranged to generate temperature data), a Global Positioning System device 226 (a positioning means arranged to generate position data) which provides the location of the vehicle), a digital clock 228 (a time generating means arranged to generate time data) and the load cell 116 via a connection 214. The keyboard 216 (an input means) allows a user to make inputs to the monitoring system 114. The input/output controller 212 also receives inputs from a vehicle log 218 which provides vehicle condition data. The vehicle log 218 is arranged to receive inputs from a tachometer, the controller 110 and other indications

of the use of the vehicle. The vehicle log 218 then comprises a driver skill monitoring system. Indications of a driver's skills may be provided by considering the average miles-per-gallon (mpg) of fuel, use of the break pedal, average speed, rests taken, a measure of the acceleration and/or deceleration, etc. A network card 222 connects the mobile computing device 114 to a network and provides a transmitter and/or receiver, for example a cellular telephone network providing a transmission medium, via a connection 220 to the aerial 108.

This embodiment will also be described with reference to a stationary computing device 300, which comprises some of the same features as the mobile computing device 114 and provides a base station. A processor 301 is connected, via a bus 302, to a memory means 304. The bus 302 also connects the processor 301 to a display driver 306, which drives a display 308 connected to an output interface 310. An input/output controller 312 is also connected to the bus 302 and to a keyboard (input means) 316 via a connection 314, and to a meter 318. The keyboard 316 allows a user to make inputs to the stationary computing device 300. The meter 318 is arranged to provide amounts of ingredients placed in the truck. A network card 322 connects the stationary computing device 300 to a network, for example a cellular telephone network which provides a communication medium for communication with the monitoring system 114, via a connection 320.

The method of the embodiment of the present invention now described comprises two monitoring systems. The first monitors the batching, mixing and delivery of concrete; the second, as summarised in the flowchart of Figure 6, monitors the condition of the vehicle 100 being used to make these deliveries.

The batching, mixing and delivery monitoring system is now described with reference to Figures 4 and 5.

The vehicle 100 arrives at a batching plant to be filled with the ingredients to make concrete (step 400). The driver of a vehicle 100 makes an entry on the keyboard 216 to signify that the vehicle 100 is at the batching plant (step 402). The mobile computing system 114 then requests and stores in its memory means 204, as step 404, the following data:

The weight of the vehicle 100 from the load cell 116; the time and date from the digital clock 228; the ambient temperature from the digital thermometer 224; the position of the vehicle 100 from the Global Positioning System device 226; and the vehicle status from the vehicle log 218.

An input is then made to the mobile computing device 114 issuing instructions to the controller 110 such that the drum 106 is driven at the appropriate speed for adding ingredients to be mixed into concrete (step 406).

The person skilled in the art will appreciate that the ingredients, usually comprising aggregate, sand, water, cement and any additives, should be mixed to produce concrete of desired strength and workability according to the proposed use of the concrete. Workability is a measure of the concrete's 'wetness', i.e. how easily the concrete flows. Strength can only be estimated at the batching plant using the ratio of ingredients. This strength must then be verified by producing test blocks which will be allowed to 'go off' (i.e. set solid). These will be tested after seven days and after twenty-four days. It is not unknown for a construction, for example a concrete bridge, to have to be demolished twenty-four days

after its construction because the test block has failed its strength test. It is therefore highly important that the concrete is of the desired strength. Generally speaking, the workability of the concrete is correlated with the strength, i.e. a runny mix is weaker than a stiff mix when the cement content of the mix is constant. A runny mix (which can be preferable for pouring) can be made stronger by adding more cement (within limits). It is therefore common practice to add more cement than it is estimated is needed for a required strength to be sure that the required strength is reached. Cement is however generally the most expensive component in concrete and has the highest environmental impact; it is therefore desirable that this practise be minimised.

The stationary computing device 300 is located at the batching plant. The amount of each ingredient added to the mixer drum 106 is recorded in the meter 318 and input into the stationary computing device 300. This will be done by recording the weight of a dispensing vessel containing the ingredient before and after the ingredient is added. The difference will give the amount by weight of the ingredient. According to usual practise, only a portion of each of the desired ingredients is added at one time, each ingredient being added in rotation until a desired total is reached. When all the ingredients are added, the meter 318 provides the total weight of each ingredient to the stationary computing device 300 (step 408), which then computes a predicted strength and workability for the mix (step 410), and transmits this information through its network connection 320 to the mobile computing device via the aerial 112 on the vehicle 100 (step 412).

The workability of the mix (also referred to as slump) is traditionally estimated by sight. An experienced worker can tell whether the mix has the desirable workability from the movement of the mix within the drum 106 by observing the angle at which the mix falls from the blades

within the drum 106. This is obviously susceptible to human error and is somewhat subjective. Further, it requires a person climbing a ladder and looking into a rotating drum, which can be dangerous. It has been recognised that the hydraulic back pressure felt by the motor 108 turning the drum 106 can be used, along with the total weight of the mix in the drum 106 and the speed at which the drum is turning, to estimate the slump in a more objective and safer manner. Finally, the workability of the mix is principally determined by the ingredients (although other factors, such as ambient temperature, may effect the workability), so an estimate can be computed using the known ingredients.

In this example, as stated above, the strength and workability of the mix are calculated. However, the estimated workability can almost immediately be verified by using the controller 110 to control the drum 106 to rotate at a known speed, and then to provide the hydraulic back pressure. This information can be used by the processing means 200 of the monitoring system 114, along with the weight of the load, to calculate a measured workability (step 414). In step 416, the monitoring system 114 compares the measured workability to the predicted workability. If the measured workability is significantly different (in this example, differs by more than 10%) from the predicted workability, then it can be assumed that an error, be it in the metering or some human error, has occurred. Perhaps more importantly, this will provide a strong indication that the mix will not produce concrete of the estimated strength. It may then be necessary to re-batch the concrete, so an error message is displayed on the screen 308 of the stationary computing device 300 (step 418).

If the estimated and measured workability are sufficiently similar, or the same, the vehicle will be ready to leave the batching plant. A message to this effect is displayed on the screen 308 of the stationary computing

device 300 (step 420). The driver of a vehicle 100 makes an entry on the keyboard 216 to signify that the vehicle 100 is ready to leave the batching plant (step 422). The mobile computing system 114 then requests and stores in its memory means 204, as step 424, the following data:

The weight of the vehicle 100 from the load cell 116; the time and date from the digital clock 228; the ambient temperature from the digital thermometer 224; the position of the vehicle 100 from the Global Positioning System device 226; and the vehicle status from the vehicle log 218 (to verify that it has been substantially stationary).

The process that follows is summarised in the flowchart of Figure 5.

The vehicle 100 travels to a delivery site. On arrival (step 500), the driver of the vehicle 100 makes an entry on the keyboard 216 to signify that the vehicle 100 is ready deliver its load (step 502). The mobile computing system 114 then requests and stores in its memory means 204 the following data, as step 504:

The weight of the vehicle from the load cell 116; the time and date from the digital clock 228; the ambient temperature from the digital thermometer 224; the position of the vehicle from the Global Positioning System device 226; and the vehicle status from the vehicle log 218, including the number of rotations recorded by the controller 110 and the parameters necessary to compute the workability of the concrete.

There are various standards that should be met before the concrete delivery takes place. In this example, the following are considered:

- Temperature. Concrete should not be laid when the ambient temperature is less than 2°C as ice crystals may form in the mix.

- Mixing. In order for so-called 'dry batch' concrete to be considered to be properly mixed, a set number of revolutions must be performed by the drum 106- in this example, that is fifty revolutions.
- Time between batching and delivery. There is a set time limit of, in this example, three hours.
- Workability. If the measured workability of the concrete has changed significantly between batching and delivery, altering by, in this example, 5% of its value at batching, this will have to be remedied.
- Strength. The strength will have to be recalculated following the addition of any component (but in particular water) to the mix.

On receipt of a user input to the keyboard 216, assessments of these criteria are made (step 506). These are displayed on the display 210 and the printer 209 of the mobile computing device 114 prints out these data, which can form a quality assurance receipt for the party taking delivery (step 508) and provides an approval recording means.

Extra ingredients may be added to the mix at this time, in step 510. The concrete in the vehicle 100 will, on occasion, be treated with various extra ingredients before being discharged from the drum 106. For example, water may be added to replace that lost to evaporation on route. Alternatively, 'admixtures', for example plasticizers or pigments may be added. It will be appreciated that this can have a significant effect on the characteristics of the concrete, and that it is desirable that these effects are known prior to laying the concrete. The amounts added should therefore be noted and input into the monitoring system 114 using the keyboard 216. The quantities are noted using a flow meter. While it is not the example discussed here, it could be that each vehicle 100 is provided with its own flow meter, which feeds data into the monitoring system 114. The quantities are then used by the processor 200 of the monitoring system 114 to compute a new estimated strength (Step 412).

The new estimated strength along with the ingredients added are stored in the memory means 204 of the monitoring system 114.

Providing that the mix meets all the required standards (step 514), a message is displayed on the display screen 210 of the monitoring system 114 (step 516). Otherwise, if the mix or environment is unsuitable, an error message is displayed and the delivery is aborted (step 518).. The driver then makes an input to the keyboard 216 of the monitoring system 114 to signify that the concrete may be off loaded (step 520). An instruction is sent to the controller 110 of the motor 108 driving the drum 106 giving the appropriate speed (and direction) of drum rotation (step 522).

When the discharge is complete, the driver makes an input to the keyboard 216 to signify this (step 524). The motor 108 is caused by the controller to stop rotating the drum 106. The vehicle 100 is then ready to leave the delivery site. The mobile computing system 114 then requests and stores in its memory means 204 the following data (step 526):

The weight of the vehicle 100 from the load cell 116; the time and date from the digital clock 228; the ambient temperature from the digital thermometer 224; the position of the vehicle 100 from the Global Positioning System device 226; and the vehicle status from the vehicle log 218.

The vehicle 100 may perform a number of such deliveries in any one day. According to another embodiment of the present invention herein described, it is further proposed that from time to time, in this example monthly, a check is carried out on the vehicle 100 and the driver. This is summarised in the flowchart of Figure 6.

This check is performed as follows, using data stored each time the state of the vehicle is recorded. In this embodiment, an input is made to the monitoring system 114 using the keyboard 216. The records regarding driver performance and the condition of the vehicle are accessed from the memory means 204 of the monitoring system 114 (step 600). The driver of the vehicle 100, and the vehicle itself will then be assessed according to the following criteria:

- Driver hours. There is currently legislation limiting both working hours and driving hours. Drivers usually keep a hand-written or electronic log. The system described herein could either replace or be used to verify this log.
- Driver performance. A useful review of the quality of driving is provided, using data such as use of the brake pedal, average mpg, etc.
- Load delivery. The records will show whether the entire load reached its proper destination on each delivery.

Software running on the processor 200 of the mobile computing device 114 is used to give the driver a score on each of these criteria (step 602). These scores are then compared to ideal scores (step 604). If his/her performance scores do not reach a required standard (step 606), the display 210 will display a message stating that he/she has failed to meet the standards and is subject to a formal performance review (step 608).

The vehicle itself is also assessed to determine whether its unloaded weight has changed (step 610). For example, it is a known problem in concrete mixer vehicles that the residue of one or more loads can build up inside the truck. This means that the truck may not be able to carry a full load and that a fuel-consuming weight is carried even when the mixer

truck is ‘empty’. Furthermore, the maximum load of a vehicle 100 can be a legal limit.

If the vehicle does not meet the required standards, then it should be sent for maintenance (step 612). Otherwise, an ‘OK’ message is displayed (step 614), indicting that the vehicle is in a fit state to continue making deliveries.

In other embodiments, readings from any of the other on-board diagnostic tools, such as air flow, engine harmonics, etc. may also be accessed and assessed.

The example discussed herein is a simple embodiment of the present invention. A number of refinements are possible without departing from the invention, and some examples of these are now discussed.

It will be readily apparent that some embodiments of the invention could also provide useful data concerning multi-drop deliveries. An interesting feature of multi-drop deliveries is that workability calculation will be carried out on part loads, so it may in these cases be advantageous to off-load the concrete through a flow meter, or to load it into a vessel that can be weighed or marked to find the amount (weight or volume) of concrete off-loaded. Alternatively, the measurements taken from the load-cell 116 may provide a sufficiently accurate measurement of the weight of the off-loaded concrete. The operation of a multi drop concrete run may reduce the cost of delivering 'part' loads in normal mixers (the load in a normal mixer is indivisible) by delivering on a 'milk round' basis, there may be less truck miles as there is no need to return to the base plant for each delivery, which may take vehicles off the road overall.

A camera could be provided use when for manoeuvring the vehicle 100, for example reversing, and the output of that camera could be sent to the display 208. The display 208 could be arranged at other times to display maps showing the local area as determined by the GPS device 226.

Furthermore, the monitoring system 114 could be arranged to periodically transmit its location as provided by the GPS device 226 through its aerial 108. It could then warn a batching plant of its approach so that preparation could be made for the batch mix required.

Further, the GPS device 226 would allow the location of the vehicle to be determined at any one time and therefore it may become easier to prevent theft of the mix. It is not unknown for drivers of vehicles to off load part of the mix they are carrying for their own profit. If the position data generated by the GPS device 226 is recorded in the memory means 204 it may be relatively easy to determine if this is occurring since it will be apparent that the driver has deviated from his route. Indeed, it may become possible to locate the stolen mix by reviewing the position data.

It is also envisaged that the system be automated and that the monitoring system 114 could be arranged to make a record without a user input. This may happen periodically or, for example, when the engine is switched on and/or switched off or at some other time.

The monitoring system 114 could further comprise alternative data input devices, for example a disc drive, or a swipe card or barcode reader. If more than one driver may operate a specified vehicle, it may be desired that they identify themselves with a swipe card or by entering an identification code on the keyboard 216. Alternatively, the function of keyboard 216 could be provided with a touch-screen or a voice-input system.

The monitoring system 114 could also be provided with navigation software, and could provide a route planning system. It could further be provided with an address book comprising contact names, telephone numbers and addresses of, for example, the person who is expecting delivery. That person could then be contacted in the event of an unforeseen delay.

It may be that the driver is monitored at all times to ensure that he/she does not exceed the maximum hours permitted by legislation. The monitoring system 114 could display a warning on the screen 210 when these limits are approached or exceeded.

The advantages of the invention as exemplified herein are many. Regulation of drivers, vehicles and concrete standards may be greatly improved by such a system.

A camera, or other remote viewing facilitation means, may be provided within the drum 106 and arranged to provide a view within the cab 104 of the inside of the vehicle.

CLAIMS

1. A concrete mixing vehicle having mounted thereon a monitoring system, said monitoring system comprising a memory means arranged to hold data, a processing means arranged to process data, a work measuring means arranged to measure at least one of the work required to mix a mix and the rate of mixing of a mix and generate work data, and a weight acquiring means arranged to acquire the weight of a mix and store in said memory weight data, said processing means being arranged to process at least one of the work data and weight data and calculate one or more parameters of a mix.

2. A concrete mixing vehicle according to claim 1 in which the processing means is arranged to calculate any one or more of the following parameters: the slump of the mix; the strength of the mix or any other parameters specific to the application of the mix.

3. A concrete mixing vehicle according to claim 1 or 2 in which the processing means is arranged to compare a parameter measured at a first time with the same parameter calculated at a second, different, time in order that differences in that parameter can be detected.

4. A concrete mixing vehicle according to any preceding claim in which the weight acquiring means is a means that determines the weight of a mix, and comprises at least one of the following: load cells, scales, an input allowing the weight of the mix to be input into the memory.

5. A concrete mixing vehicle according to any preceding claim in which the monitoring system is arranged such that the weight determined by the weight acquiring means is compared to an expected weight.

6. A concrete mixing vehicle according to any preceding claim in which the weight acquiring means comprises two or more separate means one of which is more accurate than the other.

7. A concrete mixing vehicle according to any preceding claim in which the memory means is arranged to contain data that gives the properties of a mix as the relative quantities of the one or more of the components of the mix change.

8. A concrete mixing vehicle according to any preceding claim in which the memory means may be arranged to hold the physical properties of one or more of the components.

9. A concrete mixing vehicle according to claim 8 in which said physical properties are one or more of the following: the density, the compressive strength, the moisture content, the granular size of the components.

10. A concrete mixing vehicle according to any preceding claim in which the monitoring system comprises a flow meter arranged to determine the amount of a component added to the vehicle and to generate flow data.

11. A concrete mixing vehicle according to claim 10 in which the weight acquiring means is arranged to determine the weight of a component and/or the mix by utilising the flow data generated by the flow meter.

12. A concrete mixing vehicle according to any preceding claim in which the monitoring system comprises a temperature measuring means

arranged to measure the ambient temperature and/or the temperature of the mix and to generate temperature data.

13. A concrete mixing vehicle according to any preceding claim in which the work measuring means comprises any one or more of the following: a means to measure the hydraulic pressure in a hydraulic circuit used to mix the mix (generally a hydraulic motor used to rotate a drum), a means to measure the load on an engine of the vehicle, a means to measure the power take off (PTO), a means to count a point on a mechanism past a predetermined point (for example count rotations of a drum, tooth of a drive cog, or the like).

14. A concrete mixing vehicle according to any preceding claim in which the monitoring system comprises a time generating means arranged to generate time data.

15. A concrete mixing vehicle according to claim 14 in which the time data is used by the processing means to ascertain any one or more of the following: the time of predetermined points (for example time of delivery, time load of the mix occurred, time that mixing started/stopped), time that a driver drives the vehicle.

16. A concrete mixing vehicle according to any preceding claim in which the monitoring system comprises an approval recording means arranged to record the approval of a delivery.

17. A concrete mixing vehicle according to claim 16 in which the approval recording means comprises a printing means that is arranged to print a document for signature by a person accepting the mix.

18. A concrete mixing vehicle according to claim 17 in which the printed document is arranged to contain any one or more of the following: the quantities (relative and/or absolute) for one or more of the components of the mix; one or more parameters calculated from the mix; the temperature of the mix; the location of the vehicle; the route of the vehicle; the time; the speed of the drum during delivery of the mix.

19. A concrete mixing vehicle according to any of claims 16 to 18 in which the approval recording means comprises an electronic means allowing a person to electronically record his/her approval in the memory means.

20. A concrete mixing vehicle according to any preceding claim in which the monitoring system comprises a display means arranged to display any of the data generated by the system.

21. A concrete mixing vehicle according to any preceding claim in which the monitoring system may comprise a positioning means arranged to generate position data giving the position of the vehicle.

22. A concrete mixing vehicle according to claim 21 in which said positioning means comprises a GPS receiver.

23. A concrete mixing vehicle according to claim 21 or claim 22 in which the memory means is arranged to record the position data.

24. A concrete mixing vehicle according to any preceding claim in which the monitoring system comprises a camera arranged to provide a view of a region behind the vehicle.

25. A concrete mixing vehicle according to any preceding claim in which the monitoring system comprises a camera arranged to provide a view of the inside of a drum used to mix the mix.

26. A concrete mixing vehicle according to any preceding claim in which the monitoring system comprises a transmitter and/or receiver arranged to transmit any of the data generated by any part of the monitoring system and/or receive data.

27. A concrete mixing vehicle according to any preceding claim which comprises a speed varying means which allows the speed of mixing of the mix to be controlled.

28. A concrete mixing vehicle according to claim 27 in which the monitoring system has one or more inputs to the speed varying means in order that the speed of mixing can be controlled by the monitoring system.

29. A concrete mixing vehicle according to claim 31 in which monitoring system comprises an input means comprising one or more of the following: a keyboard, a keypad, joystick, button, touch screen.

30. A concrete mixing vehicle according to claim 29in which the monitoring system has one or more inputs thereto which are arranged to provide vehicle condition data which provide an indication as to the performance of the vehicle.

31. A concrete mixing vehicle according to claim 30 in which the inputs include any one or more of the following: fuel remaining; fuel consumption; acceleration (positive and/or negative (i.e. braking)); tyre pressures.

32. A concrete mixing vehicle according to any preceding claim in which the monitoring system is arranged to record any one or more of the data items generated within the memory means.

33. A method of monitoring the mix being mixed by a concrete mixing vehicle comprising generating work data by measuring at least one of the work required to mix the mix and the rate of mixing the mix and acquiring weight data of a mix, and further, processing said weight and said work data in order to calculate one or more parameters of a mix.

34. A method of according to claim 33 which further comprises obtaining the weight data by a weighing means provided on the vehicle.

35. A method according to claim, 34 which comprises obtaining the weight data by transmission thereto.

36. A monitoring station arranged to communicate with at least one monitoring system fitted to a concrete mixing vehicle according to any of claims 1 to 32 and arranged to receive data generated by the monitoring system.

37. A monitoring system according to claim 36 in which the transmission medium includes one or more of the following; wireless telephone networks (including GSM, GPRS, UTMS), radio links, satellite links..

38. A method of monitoring at least one vehicle, and preferably a fleet of vehicles, comprising providing the or each vehicle with a monitoring system and connecting that monitoring system to a monitoring station via

a transmission medium and causing said monitoring station to receive data from the monitoring system.

39. A monitoring system suitable for fitting to a concrete mixing vehicle, said monitoring system comprising a memory means arranged to hold data, a processing means arranged to process data, a work measuring means arranged to measure at least one of the work required to mix a mix and the rate of mixing of a mix and generate work data, and a weight acquiring means arranged to acquire the weight of a mix and store in said memory weight data, said processing means being arranged to process at least one of the work data and weight data and calculate one or more parameters of a mix.

40. A method of monitoring the inside of a mixing vessel of a concrete mixing vehicle comprising placing a camera, or other remote viewing facilitation means, inside the mixing vessel.

41. A method according to claim 40 in which the mixing vessel is a drum, arranged to rotate about an axis thereof.

42. A method of increasing the safety of vehicle comprising using the display of a satellite navigation system to display the view from a camera viewing behind the vehicle and/or inside a mixing vessel of the vehicle.

43. A method of reducing the time taken to load a vehicle comprising utilising position data giving the position of the vehicle to determine when the vehicle is within a predetermined distance, or predicted time of, a site and commencing preparation to load the vehicle at that site before the vehicle arrives.

44. A monitoring system for a concrete mixing vehicle comprising a computing device arranged to receive inputs, said inputs comprising at least two of:

at least one parameter indicative of the condition of a load of concrete carried by the truck;

at least one parameter indicative of driver performance; and

at least one parameter indicative of the condition of the truck.

45. A concrete mixing vehicle substantially as described and as illustrated herein with reference to the accompanying figures.

46. A method of monitoring a mix being mixed by a concrete mixing vehicle substantially as described and as illustrated herein with reference to the accompanying figures.

47. A monitoring station substantially as described and as illustrated herein with reference to the accompanying figures.

48. A method of monitoring at least one vehicle substantially as described and as illustrated herein with reference to the accompanying figures.

49. A monitoring system substantially as described and as illustrated herein with reference to the accompanying figures.

50. A method of monitoring the inside of a mixing vessel of concrete mixing vehicle substantially as described and as illustrated herein with reference to the accompanying figures.

51. A method of increasing the safety of a vehicle substantially as described and as illustrated herein with reference to the accompanying figures.

52. A method of reducing the time taken to load a vehicle substantially as described and as illustrated herein with reference to the accompanying figures.

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Claims searched:	1-37 and 39	**Date of search:**	9 May 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance	
X	1,33,39 at least	DE 4437970 A	(SIEMENS)
Y	1,33,39 at least	GB 2329027 A	(TARMAC)
Y	1,33,39 at least	US 4900154	(WAITZINGER ET AL)
Y	1,33,39 at least	DE 4039083 A	(VALA AND DOSE)
Y	1,33,39 at least	DE 4237543 A	(KILIAN)
Y	1,33,39 at least	US 6123444	(SILBERNAGEL)
Y	1,33,39 at least	JP 090033326 A	(AOKI)
Y	1,33,39 at least	JP 090193134 A	(SANKO ET AL)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

G1N, G1S

Worldwide search of patent documents classified in the following areas of the IPC[7]:

G01N, B60P, G01L, G01G

The following online and other databases have been used in the preparation of this search report:

WPI, EPODOC, JAPIO